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IMPACT ON *POTAMOPYRGUS ANTIPODARUM* (NEW ZEALAND MUDSNAIL) FROM THE 2009 DRAWDOWN OF CAPITOL LAKE, WASHINGTON.

Potamopyrgus antipodarum (Gray, 1843). Height 4.7 mm.

Final Report
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Washington Department of Fish & Wildlife, Olympia, Washington

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TABLE OF CONTENTS

INTRODUCTION

Potamopyrgus antipodarum (Gray, 1843) has become a worldwide invasive species in fresh and brackish water habitats in Europe, Australia, Japan, and North America. In the U. S., Dwight Taylor first discovered *P. antipodarum* in the middle Snake River, Idaho (Taylor, 1987). He recognized the population as being all female (parthenogenic) and guessed the snails were from New Zealand. Since he did not see the snails during a previous survey in the area (Taylor, 1985), he estimated that the introduction possibly occurred 2-3 years previous to his discovery at The Nature Conservancy's Thousand Springs Preserve. Since it's discovery over two decades ago, it has spread to 10 western states including Washington State at Long Beach in 2002 (Davidson et al., 2008). Subsequently, on the west coast it has been reported far to the north at Port Alberni, Vancouver Island, British Columbia, Canada (Davidson et al., 2008).

Potamopyrgus antipodarum may have been introduced independently several times into the U. S. Gangloff (1998) regards the Lake Ontario (1991-1994), Idaho (1987), Lower Columbia (1997 sic) and Yellowstone National Park (1995) occurrences as separate. The Montana (Yellowstone) population is most likely derived from Idaho sources. There is also another introduction, possibly independent, in the Colorado River system in Arizona (pre-1998). Since 1998, other introductions have turned up in Owens Valley, California, Polecat Creek, Wyoming likely derived from Yellowstone populations, and in two other areas in coastal and interior Oregon (Frest & Johannes, unpub.). Ballast water is suggested venue for Lake Ontario (Zaranko et al., 1997) and generalized in Mackie (1999) but this hypothesis is untenable for most introductions, the lower Columbia being a possible exception. A map in Anderson (2006) shows introductions of *P. antipodarum* in south Puget Sound and eastern Washington, however, with the exception of Long Beach, Davidson et al. (2008) report no additional Washington sites. Several reported introductions have proven incorrect due to confusion with native hydrobiids. No native hydrobiids that can be confused with *P. antipodarum* occur in Capitol Lake. However, supposed *P. antipodarum* finds should always be confirmed by a specialist.

For the first time, the New Zealand mudsnail *Potamopyrgus antipodarum* (Gray, 1843) has been detected in the south Puget Sound region at Capitol Lake, Olympia, Washington. As a consequence of this find, U. S. Fish & Wildlife Service (USFWS), Washington Department of Fish & Wildlife (WDFW), and Washington Department of General Administration (GA), have come to together to assess the situation and come up with a plan to inform the public and government agencies, conduct surveys to determine the extent of the introduction, and to research ways to contain or control the introduction. GA, in an attempt to freeze the New Zealand mudsnails, drew down Capitol Lake by 2 feet on December 9th, 2009. In order to assess the impact of this drawdown and freezing temperatures

on *P. antipodarum* populations, samples were collected and processed by WDFW personnel. Deixis Consultants personnel examined mollusks that were sorted out.

BACKGROUND

Capitol Lake

Capitol Lake was formed when an earthen dam and concrete spillway was built in 1951 in the estuary of the Deschutes River to create a reflection pool for the Capitol building (George et al., 2006). The 260 acre artificial lake is managed by GA. Capitol Lake has posed a number of challenging management issues from sedimentation from the Deschutes River and Percival Creek to numerous introduced species (Garono et al., 2006; George et al., 2006). The lake is on the state's list of impaired water bodies. In 1997 GA invited three state agencies, the Squaxin Tribe, and four local governments be on an advisory group called the Capitol Lake Adaptive Management Plan (CLAMP) Steering Committee. Recently, CLAMP adopted a 10-year management plan (CLAMP, 2002). The plan identifies 14 objectives for improving water quality, fish and wildlife habitat, and public recreational opportunities, while managing flood control, sediment deposits and adjacent infrastructure. One possible management option in the plan is to breach the dam and return the area back to an estuary.

Capitol Lake Historic Drawdowns

Previous to the 2009 drawdown of Capitol Lake, many non-flood control drawdowns of the lake were conducted which began in 1968 (Entranco, 1997). Capitol Lake would be lowered from its summer levels to tide gate sill elevations then typically refilled with saltwater to facilitate construction, operations, and maintenance activities for the lake, shoreline, and nearby parks (Entranco, 1997); control algae and aquatic plants; to assist juvenile out-going salmonids; and reduce predatory fish presence (Hayes et al. 2008). From 1968 to 1984 drawdowns and refill with saltwater occurred up to three times annually, then twice annually from 1984 to 1995 (Hayes et al. 2008). In 1992, the Capitol Lake was filled with fresh instead of saltwater, and after 1996 the lake was only refilled with freshwater. Though regular non-flood drawdowns were discontinued after 1996, planned drawdowns occurred in 1997, 2002, 2003, and 2004 (Hayes et al. 2008).

Introductions in Capitol Lake

Even before the finding of *P. antipodarum*, introductions in Capitol Lake were one of the major concerns of the GA (CLAMP, 2002). There was at least 9 introduced species known which included Eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), American bullfrog (*Rana catesbeiana*), nutria (*Myocaster coypus*), common carp (*Cyprinus carpio*), brown bullhead (*Ameiurus nebulosus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*) (Hayes et al., 2008). In addition, Herrera (2004) reported finding two introduced mollusks, the Big-ear Radix (*Radix auricularia*) *and* Asian clam (*Corbicula fluminea*) collected in 2003. With the find of the New Zealand mudsnail (*Potamopyrgus antipodarum*), a total of three introduced mollusks are known to occur in the lake. In 2004 Capitol Lake was lowered and treated with the selective herbicide triclopyr to control a burgeoning infestation of Eurasian watermilfoil (*Myriophyllum spicatum*) (TCPHSS, 2004). One study on a Minnesota lake treated with this herbicide indicated that it had no impact on invertebrates (Petty et al., 1998).

Finding of *P. antipodarum* in Capitol Lake

During a bird-watching trip on October 22, 2009, Olympian resident Bert Bartleson (president of the Pacific Northwest Shell Club), discovered the first evidence that *P. antipodarum* had reached the North Basin of Capitol Lake at Marathon Park (Bartleson, 2010). He found 16 specimens of the New Zealand mudsnail inside a live *Anodonta* shell, which he showed to the author for confirmation on November 15th. The author contacted Kevin Aitkin (USFWS) on November 16th who subsequently contacted WDFW. As a result, GA closed Capitol Lake boat launches on November 24th and signs were posted to inform the public of the introduction.

METHODS

Field

The drawdown of Capitol Lake on December 9th by GA purposely coincided with unusually cold weather that was several degrees below freezing (**Table 6**). Transect sites were collected on Dec. 10th, 11th, and 14th by WDFW personnel from the SW corner of North Basin of Capitol Lake in an area exposed by the drawdown (**Figure 1**; **Appendix A & B**). An area of 1 m^2 was excavated at each

transect site. A total of twenty-four transect sites were collected with eight collected at the substrate surface, eight one foot below the substrate surface, and eight two feet below the substrate surface. Samples from 2 feet below the surface were not collected on December 14th. Nearshore sites were designated with "A" and those collected offshore with a "B" designation (**Figure 2**).

WDFW also conducted sampling at three sites on the Deschutes River on December 3rd and on December 9th five sites were sampled on Percival Creek and one on Capitol Lake (**Appendix A & C**).

Lab

After the benthic samples were collected, they were left to sit in the Olympia lab of WDFW for approximately 24 hrs. to allow them to reach room temperature before being sieved and picked by WDFW personnel. Stainless steel sieves were used with openings no smaller than 0.425 mm ensure no loss of mollusks. Brass sieves were not used as it can be toxic to mollusks and could possibly effect the assessment of live mollusk. Mollusks were identified by Deixis Consultant personnel in the lab of the Olympia office of WDFW on December 11th, 12th, and 15th. *P. antipodarum* were examined under a binocular dissecting microscope to determine if they were live, recent dead with a body present, recent dead empty shell, or long dead. If the snails were not crawling already, they were examined to determine for the presence of a operculum inside the aperture. If one was present and movement of the operculum was detected, or the snail emerged, the snail was considered live. If there was no movement of the operculum or from a fully or partially emergent body of a snail, when disturbed by forceps, the snail was considered recent dead with body. Empty shells with the periostracum layer present in good condition were considered recent dead empty shell. Shells with corroded periostracum or with none present were considered long dead.

RESULTS

Finds of *P. antipodarum* in Capitol Lake drainage

After the initial notification on November 16th, 2009, Will Morris (WDFW) collected snail samples on the next day from Marathon Park. WDFW identifies sample as *P. antipodarum*. On November 18th, Kevin Aitkin (USFWS) checked Tumwater Falls Park, Tumwater Historical Park, Capitol Lake at Interpretive Center, and Capitol Lake at Marathon Park. Kevin Aitkin found *P. antipodarum* at Marathon Park area of Capitol Lake only. On November 24th, 2009, an initial survey by WDFW of Capitol Lake was conducted using wading method. They also surveyed outflow of Black Lake Ditch

and Percival Creek from mouth upstream approximately 0.75 miles using snorkel method. Searches were conducted by Allen Pleus (WDFW) on December 3rd, 2009 in the Deschutes River at 3 sites (see **Appendix A** for locality descriptions). None had *P. antipodarim* present (**Appendix C**). On December 9th, 2009 five sites on Percival Creek were sampled and one additional site was surveyed in Capitol Lake at the North Basin boat launch. None of the Percival Creek sites had *P. antipodarum*, but the Capitol Lake boat launch site did (**Appendix C**). Currently, *P. antipodarum* has only been found in the S. end of the North Basin of Capitol Lake at Capitol and Percival points (**Figure 1**).

Impact of the Drawdown of Capitol Lake on *P. antipodarum*

Only the transect surface sites (1A-4B) were assessed for the number of live *P. antipodarum* found on December 10th, 11th, and 14th, 2009. All sites except 1B show a decline in number of live *P. antipodarum* from December 10th to 14th (**Figure 2-7**, **Table 5**). At site 1A, number of live *P. antipodarum* declined to zero from December 10th to 11th and none were found on the 14th (**Figure 3**). Unlike the inshore site 1A, offshore site 1B shows an increase in number of live *P. antipodarum* from December 10th to 11th, but a decline between the 11th to the 14th. Both sites show steep decline in numbers of *P. antipodarum* recent dead (w/bodies) from December 10th to 11th and less of a decline from December 11th to 14th. Sites 2A and 2B both show a decline in number of live *P. antipodarum* with less of decline in numbers from the 11th to the 14th (**Figure 4**). No recent dead (w/bodies) were found at 2A from December 10th to 11th, but recent dead (w/bodies) increased in numbers from the 11th to 14th. Offshore site 2B showed an increase in number of recent dead (w/bodies) from December 10th to 11th and a decline from the 11th to the 14th. Both sites 3A and 3B show decline in the number of live *P. antipodarum* from December 10th to 14th with a steeper decline in numbers from the 11th to the 14th (**Figure 5**). Both sites show a decrease in recent dead (w/bodies) numbers from December 10th to 11th and increase in numbers from the 11th to the 14th. No live *P. antipodarum* were found at site 4A (**Figure 6**). Site 4B shows a sharp decline in number of live *P. antipodarum* from the 10th to the 11th and less of decline in numbers from the 11th to the 14th. Both sites 4A and 4B had no recent dead (w/bodies) present from December 10th to 11th. Site 4A had a slight increase while 4B showed a slightly larger increase in number of recent dead (w/bodies) from the 11th to the 14th. **Figure 7** shows the average of the 8 sites collected at the surface for live, recent dead (w/bodies), recent dead (empty), and long dead *P. antipodarum*. This graph shows the number live decreases faster from December 10th to 11th and slightly less from the 11th to the 14th.

Mollusk Species Found In Capitol Lake

Many studies on Capitol Lake have addressed issues on restoring the lake, but few conducted formal surveys on the fauna, and none are specifically on mollusks (Hayes et al., 2008). Herrera (2004) reported finding *Radix auricularia*, *Physella*, *Corbicula fluminea*, *Gyaulus*, and *Stagnicola* in Capitol Lake from samples obtained in 2003. Below and in **Appendix B & C** is the mollusk fauna found as result of the WDFW sampling of Capitol Lake on December 3rd. 10th, 11th, and 14th, 2009.

Family Hydrobiidae

Potamopyrgus antipodarum (Gray, 1853) New Zealand mudsnail

The New Zealand mudsnail was fist noticed in the Columbia in 1995, at Youngs Bay near Astoria, Oregon (Litton, 2000; Bersine et al., 2008). Since then, it has been reported as far east as Cathlamet Bay, Oregon. Frest & Johannes (2004) extended the species range in the Columbia River eastward, to St. Helens, Oregon. Specimens at Frest & Johannes (2004) two non-estuary sites are as yet quite rare; but massive increases are likely, to judge by the species' history in the middle Snake River. It is expected that the Columbia will provide sufficient degraded habitat as to allow this taxon to become a true nuisance species. While Mackie (1999) does not seem to regard this taxon as nuisance, except possibly to native mollusks, experiences in the middle Snake River (Bowler & Frest, 1992; Frest & Johannes, 1992) suggest that it not only negatively impacts native mollusks but also can be both an aesthetic irritant and impediment to hydroelectric, trout rearing, and irrigation facilities. Aside from impacts on native species (USFWS, 1995; Richards et al., 2001: see also earlier references in Frest et al., 2002), the species is a biofouler. At one Idaho Power hydroelectric facility, for example, it has proved necessary to operations to remove some 30 tons of organic detritus per day. Half of that by weight is *P. antipodarum*. The further spread of *Potamopyrgus antipodarum* has been a concern of Washington State legislature since 2008 (ANSC, 2007). In Capitol Lake it is estimated the population densities are 20,000 per square meter in limited areas of the North Basin (Allen Pleus, pers. comm.). Based on the extent of the area invaded and population density of *P. antipodarum* in Capitol Lake, introduction probably occurred in 2008 or 2009.

Family Lithoglyphidae

Fluminicola n. sp. unnamed pebblesnails

About 7 undescribed taxa known over the state; range from common to highly restricted; see

Frest & Johannes (1995, 2004) and Hershler et al. (2007) for details. One taxon in this group was reported from Okanogan R. by Frest & Johannes (1995); see also Neitzel & Frest (1993). *Fluminicola* is likely to be a large and complex genus when revision is completed (Hershler & Frest, 1996). The genus as now defined is likely not monophyletic. Many taxa are spring snails, but Washington undescribed taxa are mostly amniphiles. For DNA phylogeny see Hershler et al. (2007). *Fluminicola* was not found in Capitol Lake but occurs in the Deschutes River (see **Appendix C**).

Family Semisulcospiridae

Juga (Juga) n. sp. unnamed juga

This species was not found at the transect sites on Capitol Lake, but found at another site collected in Capitol Lake by Allen Pleus of WDFW (see **Appendix C**). *Juga* can be found in lakes, but generally are found in creeks, rivers, and springs. The occurrence of *Juga* in Capitol Lake is not unexpected, since the Deschutes River empties into lake. *Juga* were also found in Percival Creek (see **Appendix C**).

Family Lymnaeidae

Radix auricularia (Linnaeus, 1758) Big-ear Radix

This Euarasian aquarium species was first collected from the Great Lakes in 1901 (Mills et al. 1993). This taxon is now widely introduced over the whole State and is similarly common elsewhere in the western U. S. While most likely to be found in relatively quiet situations on soft substrates, often with common macrophytes, this taxon is effectively a poikilothermophile and has been noted from streams of all sizes, lakes, ponds, and springs, spring runs, and spring pools. It appears most successful in warmer areas with little current and definite nutrient enrichment; and has even been seen occasionally in cattle troughs. While often an epiphyte scraper, then species is also believed to be able to survive on aquatic macrophytes.

Note that Taylor (1981) has sometimes considered the species, at least in Alaska, native. However, its rapid spread in much of the western U. S. in recent years suggests that it was not recently present historically. Has been noted by Frest & Johannes (unpub.) at a number of sites elsewhere in the State, especially in eastern Washington. Capitol Lake is a perfect habitat for this introduced species but it has not become a major component of the benthic fauna of the lake. First reported in the lake in 2003 (Herrera, 2004).

Stagnicola (Stagnicola) elodes (Say, 1821) marsh pondsnail

This is one of the most widespread snails that occur in one form or another over most of North America. The taxonomy is as yet poorly understood, and many local forms have been named (Burch, 1989). It is less common in the western U. S., where it is replaced partially by the similar *S. traski.* The marsh pondsnail is a poikilothermophile, usually an epiphyte and macrophyte feeder. It is often found in soft substrate areas, frequently shallow water, with common emergent plants and aquatic macrophytes, such as quiet streams and water bodies of all sizes, including marshes, fens, and swamps; and sometimes including ditches, even those that occasionally dry up.

Family Physidae

Physella (Physella) gyrina (Say, 1821) tadpole physa

Physids are among the common snails in the Western U. S., as they are in the East as well. Taxonomy is badly in need of revision; and here Taylor (1981) and Burch (1989) are followed, both recognizing a small number of taxa in the West. Forms of *gyrina* are widespread in a variety of habitats in Western North America. Many literature reports are more likely ascribable to *Physella (Physella) propinqua*. This taxon seems to prefer small stream, pond, and lake habitats locally.

Family Planorbidae

Planorbella (Pierosoma) occidentale (Cooper, 1870) no common name

This is a very widespread western form occupying a position similar in ubiquity to that of the eastern form *P. trivolvis*. It lives in much of the U. S. from the Rocky Mountains to the Pacific Coast and in the western half of Canada. This taxon can tolerate a wide temperature range but is replaced by other forms in southern California and some of the Southwest. Found especially on aquatic macrophytes in areas with muddy substrates; most frequently in rather shallow water and in lower velocity settings, such as ponds, lakes, marshes, cut-offs, ditches, and sloughs (all permanent settings).

Family Unionidae

Anodonta oregonensis (Lea, 1838) Oregon floater

The mussel termed the Oregon floater was first described from the lower Columbia River but

appears currently uncommon to rare in it. Formerly rather widespread, it is found over much of Washington and Oregon, although seldom in large numbers. Along the Cascade axis, it seems to be replaced by *Anodonta kennerlyi*, and is more often found in streams than that largely lentic taxon. Only dead shells or fragments were found in Capitol Lake during this project. However, Bert Bartleson found a live *Anodonta* (most likely *oregonensis*) in Capitol Lake (Bartleson, 2010).

Family Corbiculidae

Corbicula fluminea (Müller, 1774) Asian clam

Corbiculids were native residents of North America for a considerable time before becoming extinct on the continent relatively recently (Taylor, 1988a, b). The first known introduction, in North America, occurred in the Columbia River and it has been known to be present there since perhaps 1937 (Burch, 1944; Counts, 1985). Since its introduction, it is now found in 38 states and the District of Columbia (Foster et al. 2009). It can be a major biofouler of intakes (Insom, 1986; Insom et al., 1986). Its method of dispersal in North America is not well understood.

Taxonomic status of *Corbicula* in North America is still somewhat cloudy, with claims for at least two taxa**.** More recently, morphological differences within the introduced populations have been ascribed to origin as separate clones of uncertain number, distribution, and status. Despite the early introduction, *Corbicula* is only moderately successful as an invader in Washington and Oregon, especially as compared with, say, the Tennessee Valley. It is a pest species with considerable economic impact in the central and eastern states. In Capitol Lake, it does not occur in great numbers. First reported in the lake in 2003 (Herrera, 2004).

Family Sphaeriidae

Musculium raymondi (Cooper, 1890) western lake fingernailclam

Most often seen in the literature as *Musculium lacustre* (Müller 1774) (lake fingernailclam); Taylor (1981) argues that the western form is distinct. As this common name would suggest, this taxon is most often found in lentic habitats, or at least in low flow situations. *Lacustre* is a frequently seen taxon in eastern and central North America in warm-water, soft-sediment situations but *raymondi* is rather uncommon in the West (Frest & Johannes, 2001). Here, it is often a lake form and occasionally an impoundment or reservoir (or similar habitat) form. Herrera (1997 & 2004) reported Sphaeriidae from Capitol Lake but do not identify what species they found.

CONCLUSIONS

The December 9th, 2009 drawdown of Capitol Lake and freezing temperatures effectively reduced the number of live *P. antipodarum* at seven of the eight sample sites by over 99% (**Figure 3-7, Table 5**). No live *P. antipodarum* were found at one site (4A) possibly indicating that they either all died before sampling commenced or none were living at that site. There is a rough correlation between offshore and inshore sites and number of live *P. antipodarum* found. More live were found at offshore sites than inshore sites except for sites 3A and 3B in which the opposite was the case. This may reflect the fact that inshore sites first emerged and were exposed to freezing temperatures longer than the offshore sites. During the drawdown on the 9th, both the high and low air temperatures were below freezing (**Table 6**). A high for air temperatures from the 10th to the 13th were above freezing but lows and the average air temperatures were well below freezing. On the 14th both the low and high air temperatures were above freezing (**Table 6**). It is possible that the increase in air temperatures may have reduced the mortality rate between the 11th and 14th (**Figure 7**). Whether a wintertime drawdown during a freeze is more effective than a summertime drawdown during a heat wave; or an intentional saltwater incursion of Capitol Lake; or use of chemicals in reducing or possibly eliminating *P. antipodarum* populations needs to be investigated.

A drawdown of Capitol Lake occurred during the summer of 1996 (Herrera, 1996). Unlike the results of this study, benthic invertebrate sampling before and after the drawdown and refilling of Capitol Lake indicated it did not have any impact on species diversity or densities (Herrera, 1996). However, the species listed by Herrera (1996) are ones very tolerant of drastic environmental changes and could survive the numerous intentional drawdowns and saltwater refills of Capitol Lake that occurred before 1996 (Entranco, 1997). With the commencement of freshwater refilling of Capitol Lake in 1996, the fauna changed from a depauperate widely environmentally tolerant one to a somewhat more diverse freshwater one (Herrera 1996, 2004). It is possible this change to freshwater refilling of Capitol Lake may have helped *P. antipodarum* to more likely to survive and multiply when it was introduced into the lake.

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REFERENCES

Anderson, T. R. 2006. New Zealand Mudsnail *Potomopyrgus* [sic] *antipodarum*, pp. 102-103. *in* Boersma, P. D., S. H. Reichard, and A. N. Van Buren, *Invasive Species in the Pacific Northwest*. University of Washington Press, Seattle, Washington. xxv + 285.

ANSC. 2007. Washington State Aquatic Nuisance Species Committee Report to the 2008 Legislature. Prepared by P. Meacham and A. Pleus. Washington Department of Fish and Wildlife. x + 58 pp

Bartleson, B. 2010. New Zealand Mudsnails Found in Capitol Lake, Olympia. The Dredgings 50(1): 7-8.

Bersine K., V. E. Brenneis, R. C. Draheim, A. M. Wargo Rub, J. E. Zamon, R. K. Litton, S. A. Hinton, M. D. Sytsma, J. R. Cordell, and J. W. Chapman. (2008) Distribution of the invasive New Zealand mudsnail (*Potamopyrgus antipodarum*) in the Columbia River Estuary and its first recorded occurrence in the diet of juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Biological Invasions 10: 1381-1388.

Bowler P. A. (1991) The rapid spread of the freshwater hydrobiidae snail *Potamopyrgus antipodarum* (Gray) in the Middle Snake River, southern Idaho. Proceedings of the Desert Fishes Council 21: 173–182.

Bowler, P. A. and T. J. Frest. 1992. The Non-Native Snail Fauna of the Middle Snake River, Southern Idaho. Desert Fishes Council, Proceedings 23: 28-44.

Burch, J. Q. 1944. Checklist of west American mollusks. Minutes, Concological Club of southern California 38:18.

Burch, J. 1989. *North American Freshwater Snails*. Malacological Pubilications, Hamburg, MI. vii + 365 pp.

CLAMP, 2002. Capitol Lake Adaptive Management Plan. A Vision for the Next Ten Years 2003-2013. Washington State Department of General Administration, Capitol Lake Adaptive Management Committee, Olympia, Washington. 55 pp.

Counts, C. L. III. 1985. Corbicula fluminea (Bivalvia: Corbiculidae) in the state of Washington in 1937, and in Utah in 1975. Nautilus 99:18-19.

Davidson T. M., V. E. F. Brenneis, C. de Rivera, R. Draheim, and G. E. Gillespie. 2008. Northern range expansion and coastal occurrences of the New Zealand mud snail *Potamopyrgus antipodarum* (Gray, 1843) in the northeast Pacific. Aquatic Invasions 3: 349-353.

Entranco. 1997. 1997 Capitol Lake Drawdown Monitoring Results: Capitol Lake Adaptive Management Plan. Prepared for the Capitol Lake Adaptive Management Plan Steering Committee, Olympia, Washington. Entranco, Bellevue, WA. 30 pp. + appendices.

Frest, T. J. and E. J. Johannes. 1992. Distribution and ecology of the endemic and relict mollusc fauna of Idaho TNC's Thousand Springs Preserve. Final Report prepared for The Nature Conservancy of Idaho. Deixis Consultants, Seattle, Washington. iii + 291 pp.

Frest, T. J., and E. J. Johannes. 1995. Interior Columbia Basin mollusk species of Special Concern. Final Report prepared for Interior Columbia Basin Ecosystem Management Project, Walla Walla, Washington. Deixis Consultants, Seattle, Washington. xi + 274 pp., appendices. Available at http://www.icbemp.gov/science/frest_1.pdf and http://www.icbemp.gov/science/frest_2.pdf] (Accessed 27 February 2009)

Frest, T. J. and E. J. Johannes. 2001. An Annotated Checklist of Idaho Land and Freshwater Mollusks. Idaho Academy of Science, Journal, 36(2): 1-51.

Frest T. J. and E. [J] Johannes. 2004. Some freshwater mollusks of the Lower Columbia River, Oregon and Washington, 69-88, *in* Sytsma M. D., J. R. Cordell, J. W. Chapman, and R. C. Draheim, Lower Columbia River Aquatic Nonindigenous Species Survey 2001-2004. Final Technical Report: Appendices. Prepared for the United States Coast Guard and the United States Fish and Wildlife Service. Center for Lakes and Reservoirs, Portland State University, Portland, Oregon, iii + 164 pp. Available at http://www.clr.pdx.edu/docs/LCRANSFinalReportAppendices.pdf (Accessed 27 February 2009)

Frest, T. J., E. J. Johannes, W. H. Clark, G. Stevens, and M. G. Plew. 2002. A Bibliography of Idaho Freshwater and Terrestrial Mollusks. Idaho Academy of Science, Journal, 37(2): 9-120.

Foster, M., P. Fuller, A. Benson, S. Constant, and D. Raikow. 2009. *Corbicula fluminea*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Available at http://nas.er.usgs.gov/queries/ FactSheet.asp?speciesID=92. Revision Date: 6/22/2009. (Accessed 19 December 2009)

Gangloff, M. M. 1998. The New Zealand Mud Snail in Western North America. ANS [Aquatic NuisanceSpecies] Digest 2(3): 27-30.

Garono, R. J., E. Thompson, and M. Koehler. 2006. Deschutes River Estuary Restoration Study Biological Conditions Report. Final Report to Thurston Regional Planning Council. Wetland & Watershed Assessment Group, Earth Design Consultants, Inc. Corvallis, Oregon. xii + 126 pp.

George, D. A., G. Gelfenbaum, G. Lesser, and A. W. Stevens. 2006. Deschutes Estuary Feasibility Study: Hydrodynamics and Sediment Transport Modeling. USGS Open-File Report 2006-1318. xvi + 202 pp.

Hayes, M. P., T. Quinn, and T. L. Hicks. 2008. Implications of Capitol Lake Management for Fish and Wildlife. Final Report to Capitol Lake Adaptive Management Program Steering Committee, Olympia, Washington. Washington Department of Fish and Wildlife, Olympia, Washington. iv + 93 pp.

Herrera. 1996. Capitol Lake 1996 Drawdown—Water Quality Monitoring Report. Prepared for Washington Department of General Administration, Olympia, Washington. Herrera Environmental Consultants, Inc., Seattle, Washington. iii + 35 pp., appendices.

Herrera. 2004. Capitol Lake Vertebrate and Invertebrate Inventory. Prepared for Washington Department of General Administration, Olympia, Washington. Herrera Environmental Consultants, Inc., Seattle, Washington. iii + 41 pp., appendices.

Hershler, R. and T. J. Frest. 1996. A Review of the North American Freshwater Snail Genus *Fluminicola* (Hydrobiidae). Smithsonian Contributions to Zoology 583. iii + 41 pp.

Hershler, R., H.-P. Liu, T. J. Frest, and E. J. Johannes. (2007). Extensive diversification of pebblesnails (Lithoglyphidae: *Fluminicola*) in the upper Sacramento River Basin, northwestern USA. Zoological Journal of the Linnaean Society of London, 149: 371-422.

Isom, B.G. 1986. Historical review of Asiatic clam (*Corbicula*) invasion and biofouling of waters and industries in the Americas. American Malacological Bulletin, Special Edition No. 2: 1-5.

Isom, B. G., C. F. Bowman, J. T. Johnson, and E. B. Rodgers. 1986. Controlling *Corbicula* (Asiatic clams) in complex power plant and industrial water systems. American Malacological Bulletin, Special Edition 2: 95-98.

Litton, R. K. (2000) Youngs Bay benthic invertebrate survey study 2000. Report to Oregon Department of Environmental Quality.

Mackie, G. L. 1999. Ballast Water Introduction of Mollusca, pp. 219-254, *in* Claudi, R., and J. H. Leach, *Nonindigenous freshwater organisms: vectors, biology, and impacts*. Lewis Publishers: Boca Raton, Florida. 8 unnumbered + 464 pp.

Mills, E. L., J. H. Leach, J. T. Carlton, and C. L. Secor. 1993. Exotic species in the Great Lakes: A history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19: 1-54.

Neitzel, D. and T. J. Frest. 1993. Survey of Columbia River Basin Streams for Columbia Pebblesnail *Fluminicola columbiana* and Shortface Lanx *Fisherola nuttalli*. Battelle Pacific Northwest Laboratory PNL-8229. Rev. 1 ix + 29 pp., Appendix A, 24pp, Appendix B, 25 pp.

Petty, G. A., K. D. Getsinger, J. D. Madsen, J. G. Skogerboe, W. T. Haller, A. M. Fox, and B. A. Houtman. 1998. Aquatic Dissipation of the Herbicide Triclopyr in Lake Minnetonka, Minnesota. US Army Corps of Engineers, Waterways Experiment Station, Aquatic Plant Control Research Program, Vicksburg, Mississippi. Technical Report A-98-1. xii + 96, appendices.

Richards, D. C., L. D. Cazier [now Shinn, D. C.], and G. T. Lester. 2001. Spatial Distribution of Three Snail Species, Including the Invader *Potamopyrgus antipodarum,* in a Freshwater Spring. Western North American Naturalist 61(3): 375-380.

Taylor, D. W. 1981. Freshwater mollusks of California: a distributional checklist. California Fish & Game 67(3): 140-163.

Taylor D. W. 1985. Candidate threatened or endangered molluscs in Box Canyon ACEC, Gooding County, Idaho. Unpublished Report to Bureau of Land Management, Shoshone, Idaho. 19 pp.

Taylor D. W. 1987. Thousand Springs Preserve threatened or endangered snails. Unpublished Report to The Nature Conservancy, Sun Valley, Idaho, 2 pp.

Taylor, D. W. 1988a. Aspects of Freshwater Mollusc Ecological Biogeography. Palaeogeography, Palaeoclimatology, Palaeoecology 62: 511-576.

Taylor, D. W. 1988b. Phylum: Mollusca, pp. 33-57, *in* J. Gray (ed.) Evolution of the freshwater ecosystem: the fossil record. Palaeogeography, Palaeoclimatology, Palaeoecology 62: 1-214.

TCPHSS. 2004. Capitol Lake Milfoil Control Project Monitoring Report. Thurston County Public Health and Social Services, Olympia, Washington. 5 pp. + appendices.

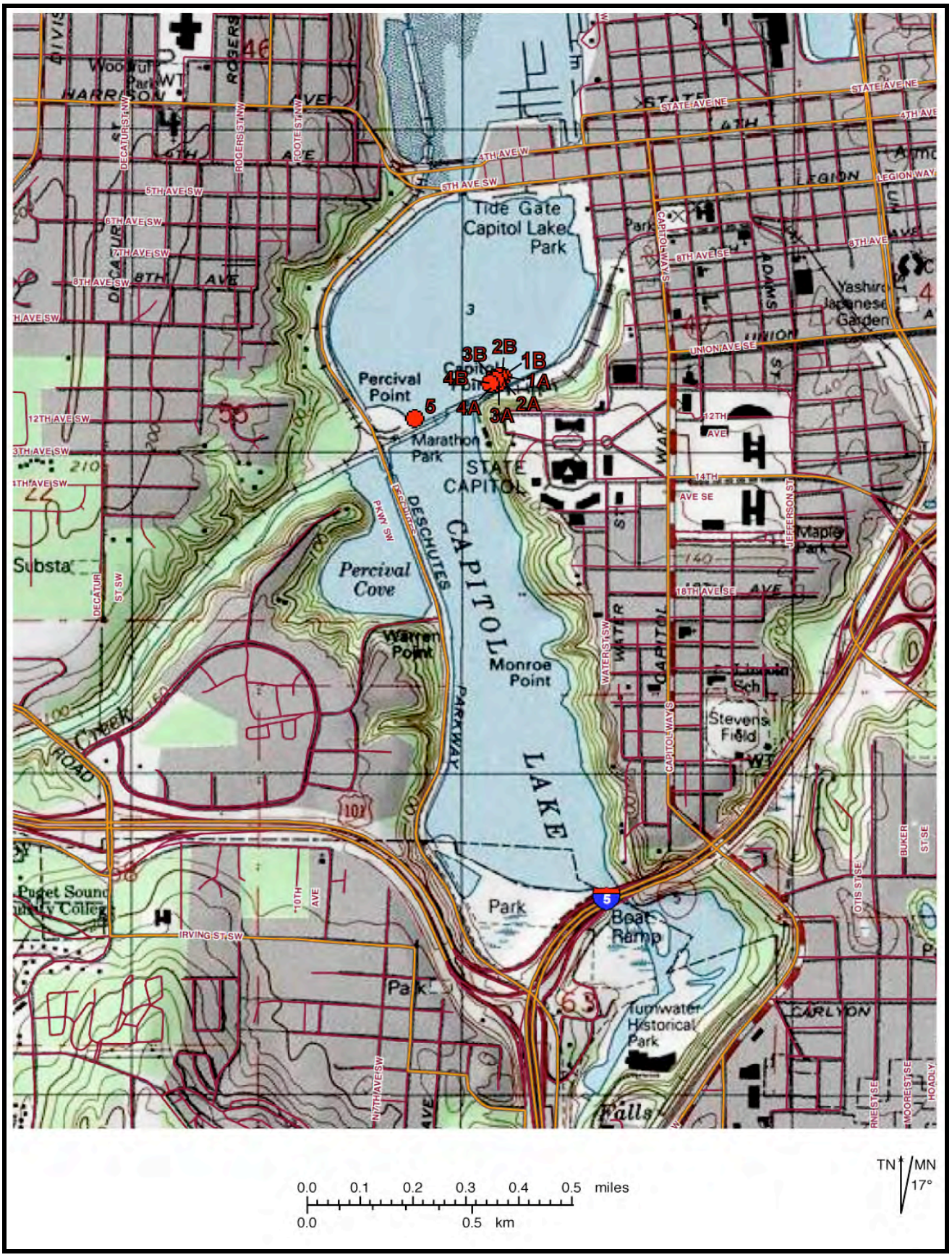
USFWS. 1995. Snake River Aquatic Species Recovery Plan. Ecological Services, Snake River Basin Office, U. S. Fish and Wildlife Service, Boise, Idaho. vi + 92 pp.

Zaranko, D. T., D. G. Farara, and F. G. Thompson. 1997. Another exotic mollusc in the Laurentian Great Lakes: the New Zealand native *Potamopyrgus antipodarum* (Gray 1843) (Gastropoda, Hydrobiidae). Canadian Journal of Fisheries and Aquatic Sciences 54(4): 809-814.

FIGURES

FIGURE 1.
MAP OF CAPITOL LAKE SITES WHERE *POTAMOPYRGUS ANTIPODARUM* WAS FOUND.

1A-4B are WDFW sites and site 5 is the first site *P. antipodarum* was found by Bert Bartelson. See Appendix A and Appendix B for site coordinates and descriptions.


Tide Gate
Capitol Lake
Park
Percival
Point
Marathon
Park
STATE
CAPITOL
Percival
Cove
Warren
Point
Monroe
Point
CAPITOL
LAKE
Stevens
Field
Park
Boat
Ramp
Tumwater
Historical
Park
Falls
Puget Sound
Community College
Yashiro
Japanese
Garden
Maple
Park
Substa
Creek
ROAD
PARKWAY
DESCHUTES
CAPITOL WAYS
WATER ST SW
JEFFERSON ST
STATE AVE NE
4TH AVE W
5TH AVE SW
6TH AVE SW
7TH AVE SW
8TH AVE SW
8TH AVE SE
UNION AVE SE
12TH AVE SW
12TH AVE
14TH AVE SE
16TH AVE SE
IRVING ST SW
17TH AVE SW
10TH AVE
DECATUR ST SW
ROGERS ST NW
FOOTE ST NW
ADAMS ST
LEGION WAY
CARLYON
OTIS ST SE
BUKER ST SE
MOORE ST SE
HOADLY
1A
1B
2A
2B
3A
3B
4A
4B
5
0.0 0.1 0.2 0.3 0.4 0.5 miles
0.0 0.5 km
TN
MN
17°

F2

FIGURE 2. CAPITOL LAKE SITES COLLECTED BY WDFW. TOP IS NORTH.

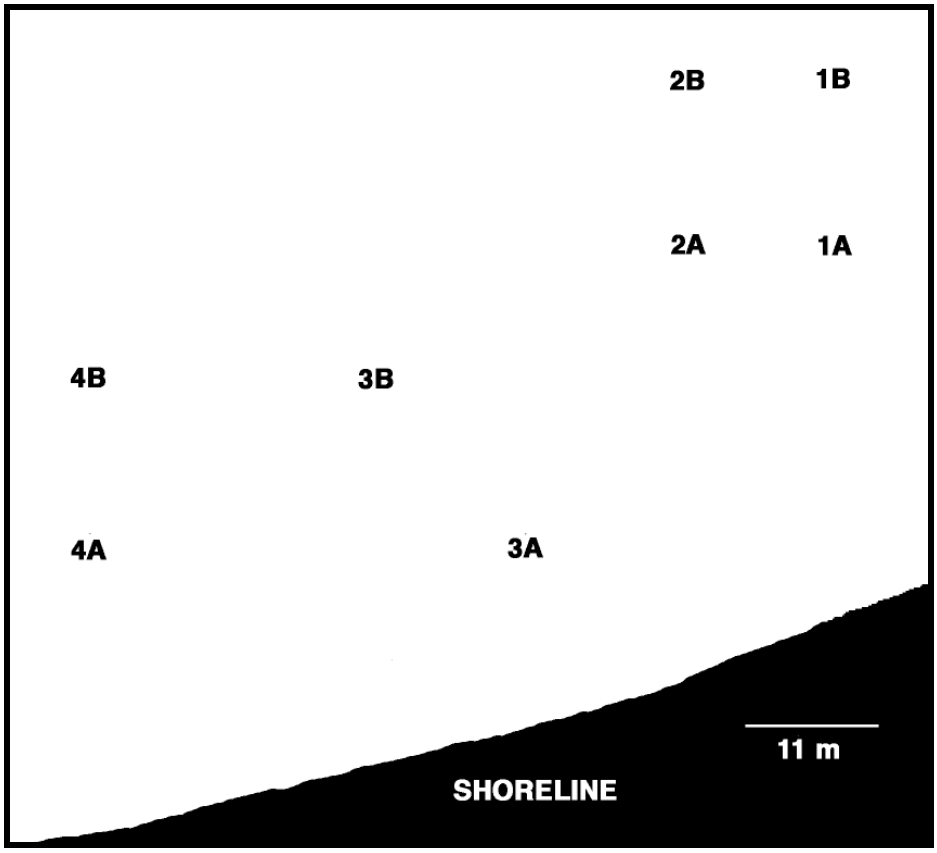
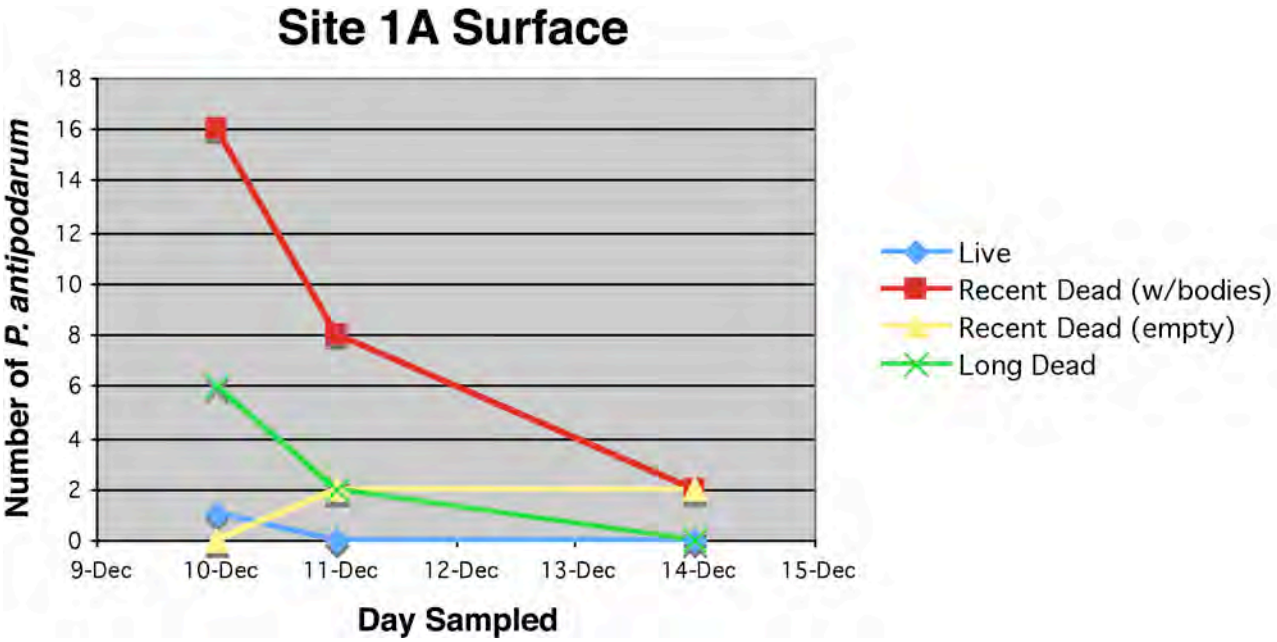


FIGURE 3. GRAPHS OF NUMBER OF *P. ANTIPODARUM* LIVE, RECENT DEAD WITH BODIES, EMPTY RECENT DEAD, AND LONG DEAD AT SITES 1A AND 1B SURFACE.



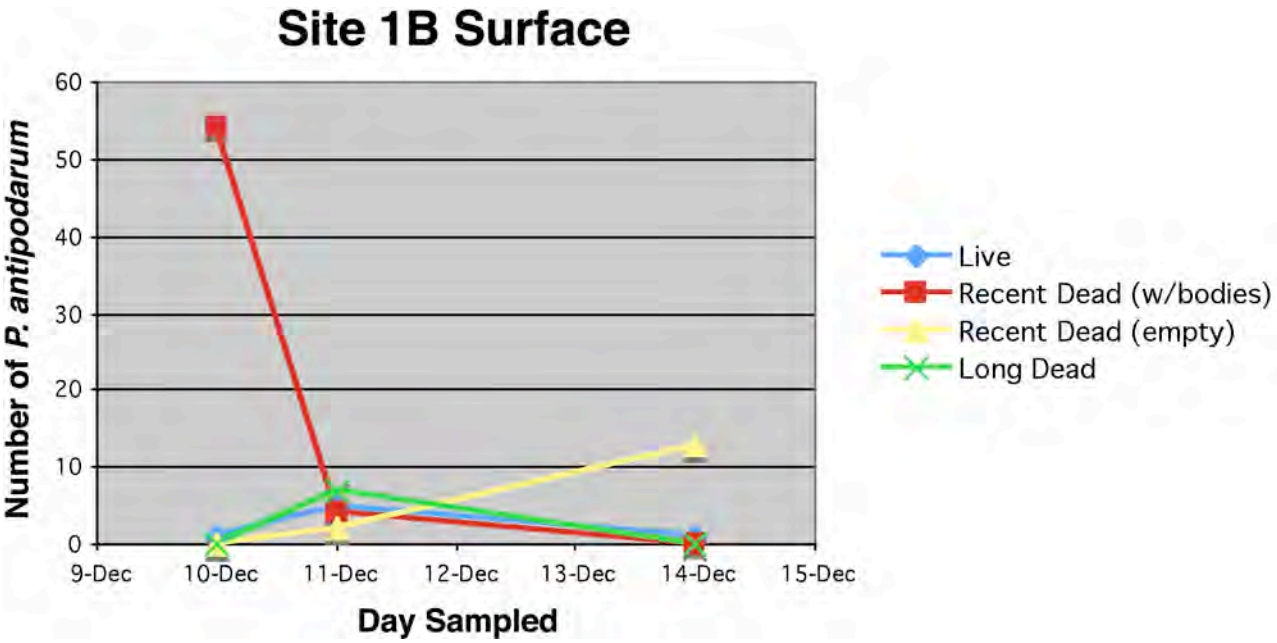
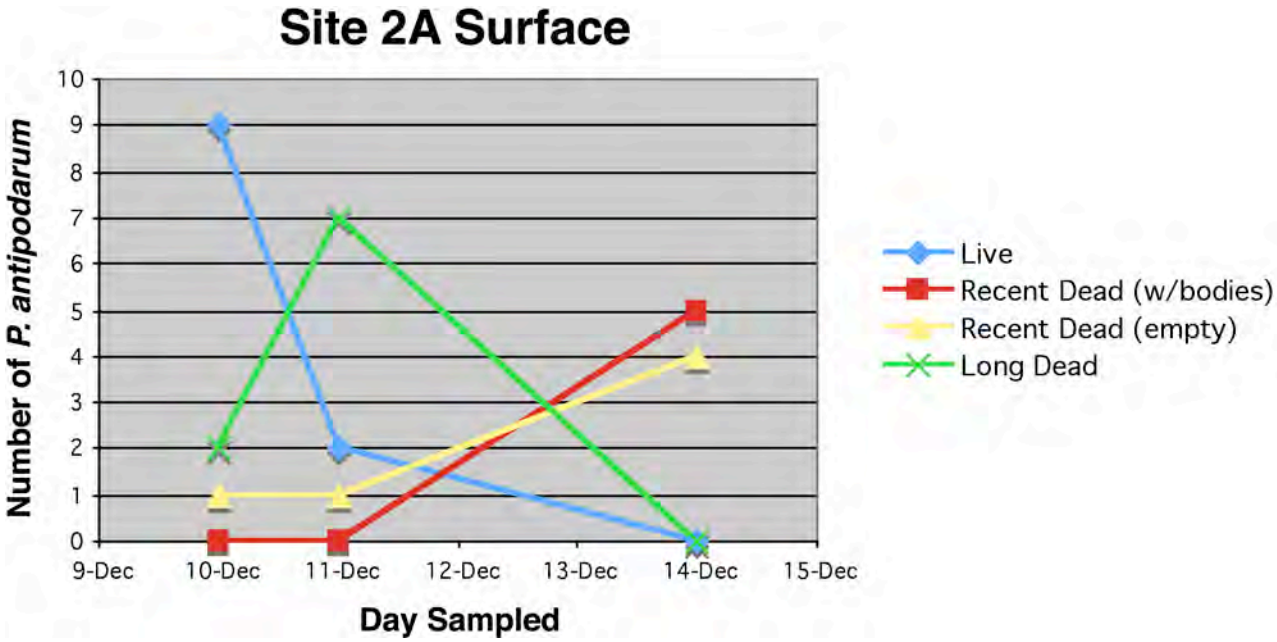


FIGURE 4. GRAPHS OF NUMBER OF *P. ANTIPODARUM* LIVE, RECENT DEAD WITH BODIES, EMPTY RECENT DEAD, AND LONG DEAD AT SITES 2A AND 2B SURFACE.



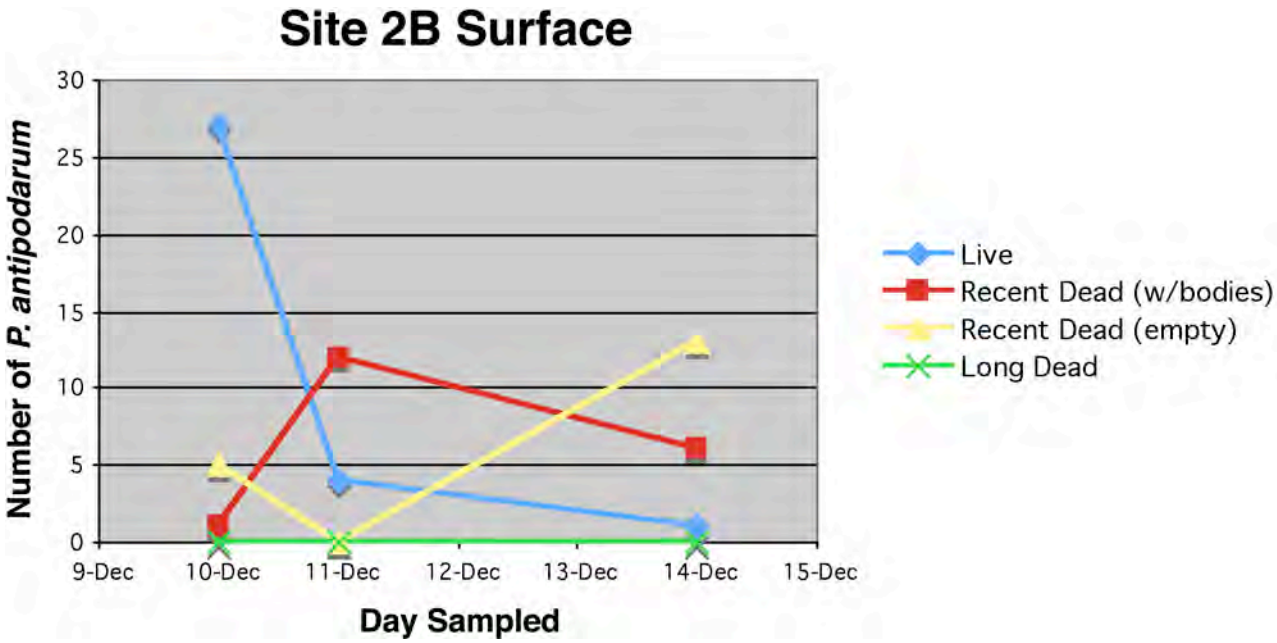
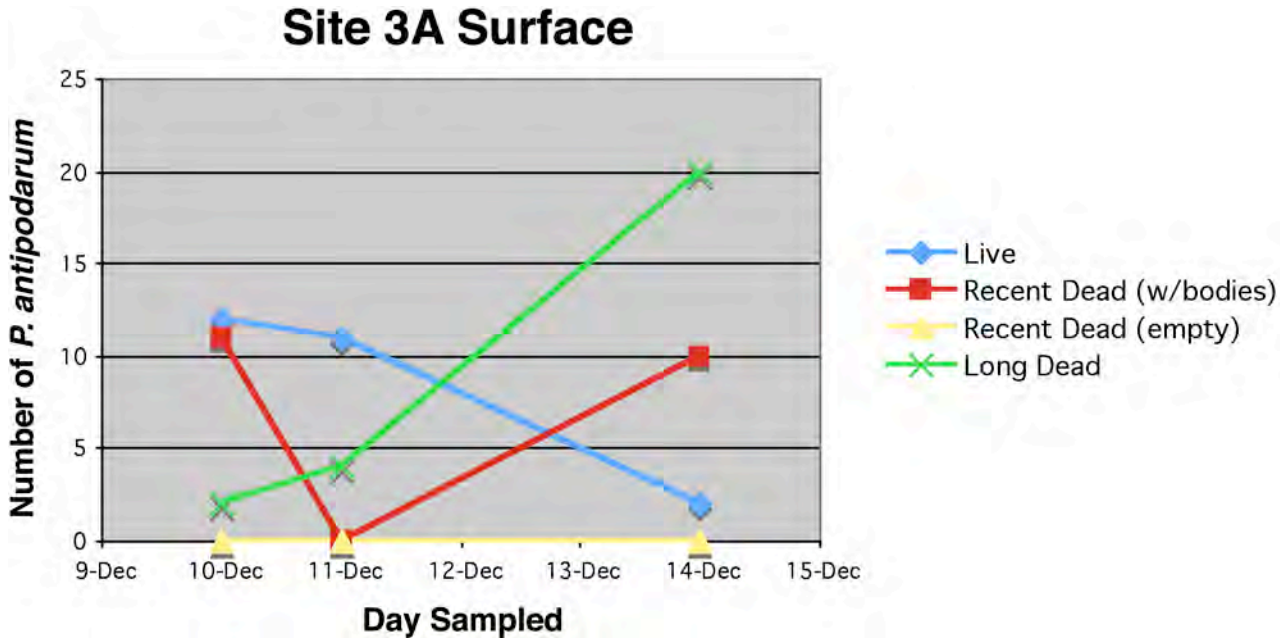


FIGURE 5. GRAPHS OF NUMBER OF *P. ANTIPODARUM* LIVE, RECENT DEAD WITH BODIES, EMPTY RECENT DEAD, AND LONG DEAD AT SITES 3A AND 3B SURFACE.



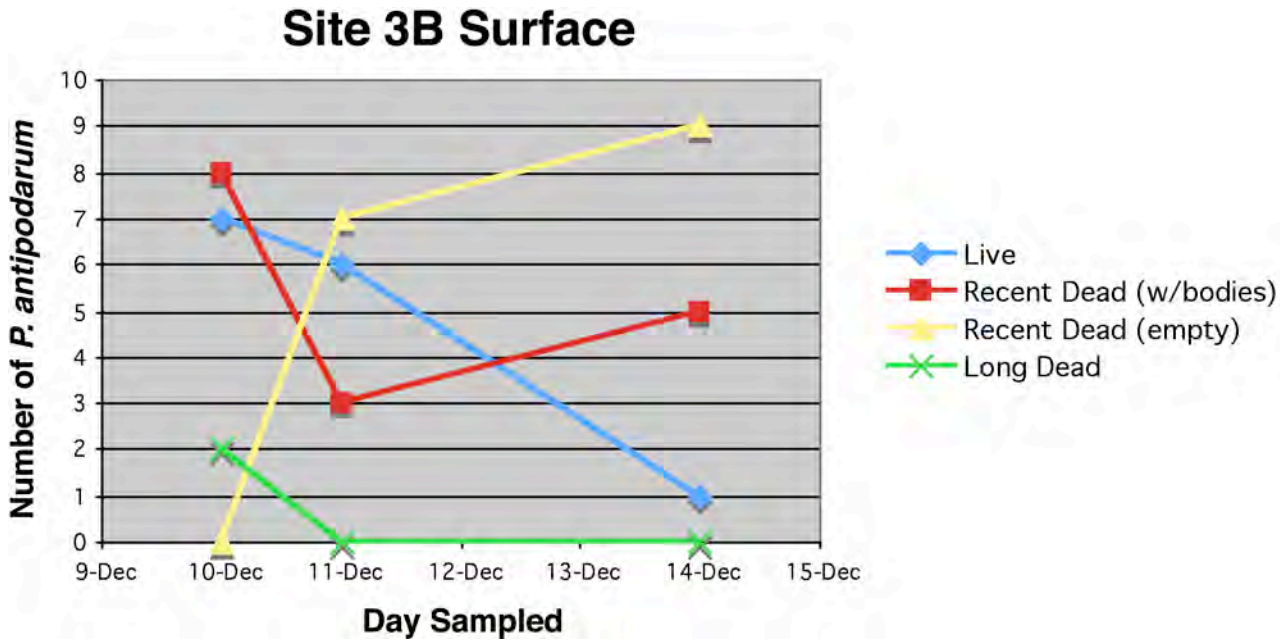
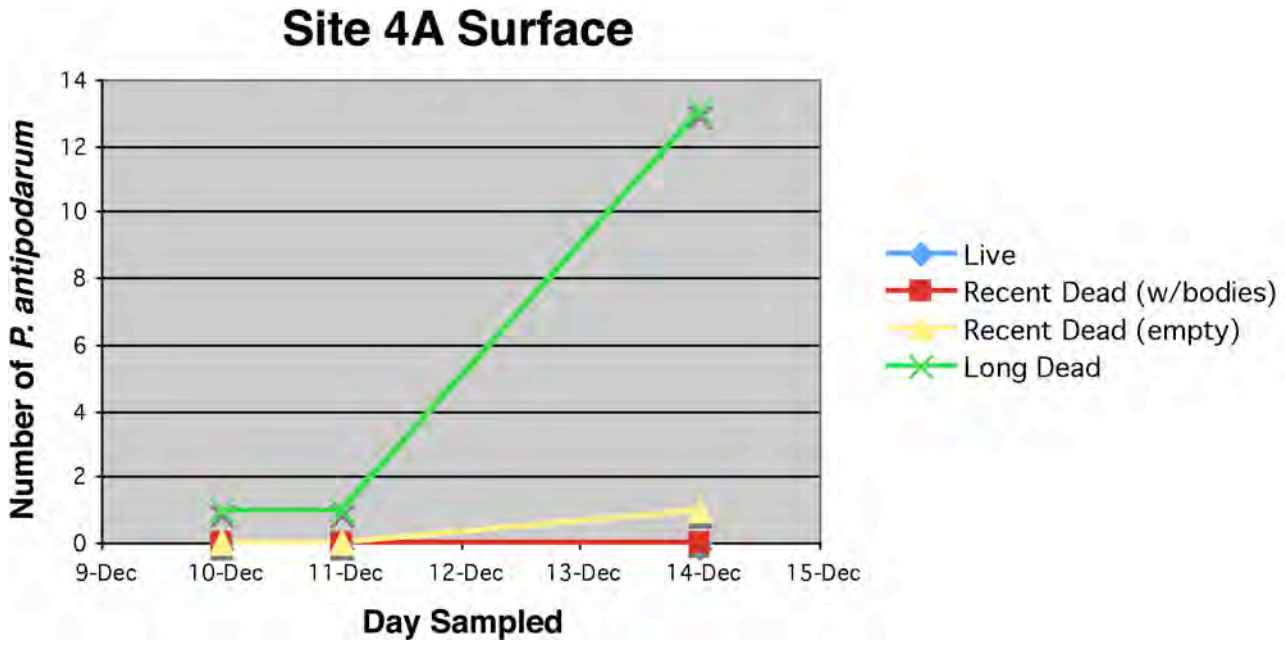


FIGURE 6. GRAPHS OF NUMBER OF *P. ANTIPODARUM* LIVE, RECENT DEAD WITH BODIES, EMPTY RECENT DEAD, AND LONG DEAD AT SITES 4A AND 4B SURFACE.



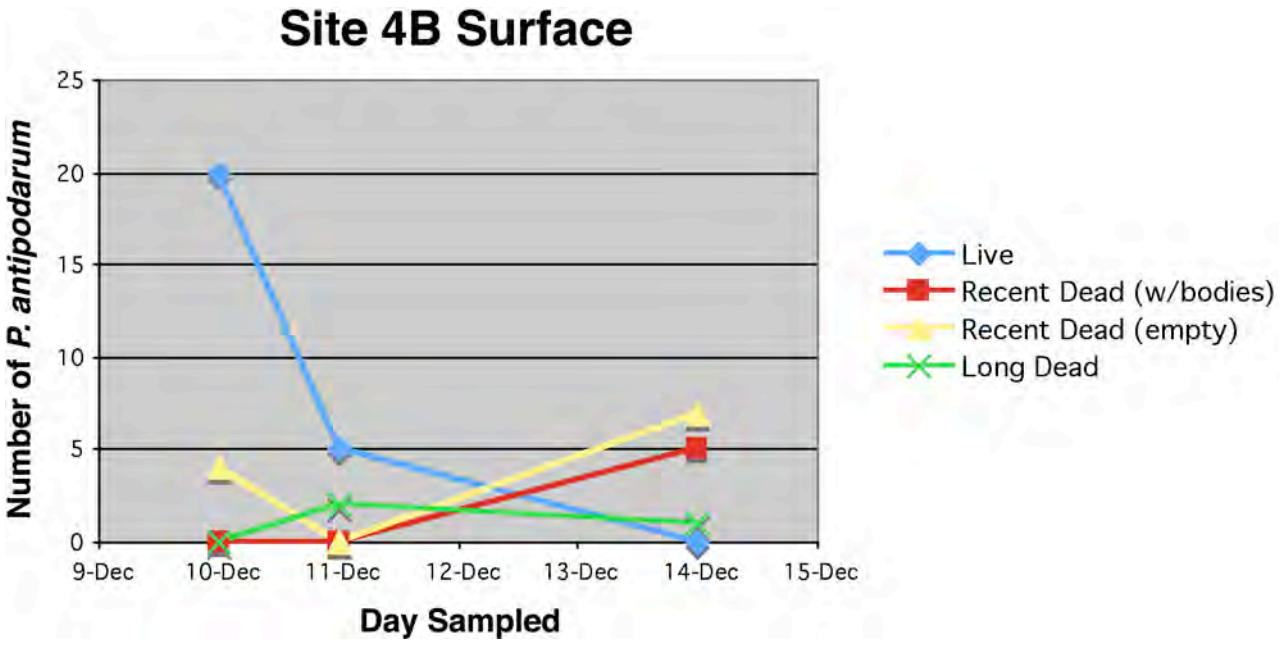
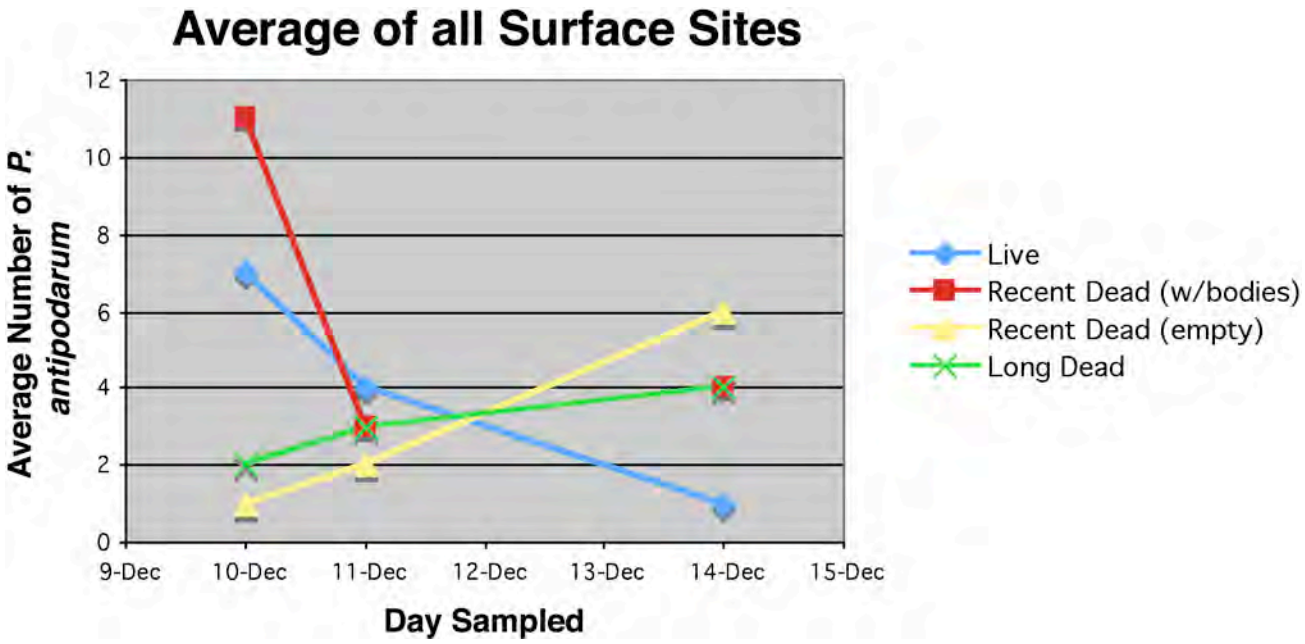


FIGURE 7. GRAPH OF ALL SURFACE SITES AVERAGE NUMBER OF *P. ANTIPODARUM* LIVE, RECENT DEAD WITH BODIES, EMPTY RECENT DEAD, AND LONG DEAD.



APPENDIX A: SITE DESCRIPTIONS.

1A, 1B, 2A, 2B, 3A, 3B, 4A, & 4B) Capitol Lake transect sites, North Basin at Capitol Point, Olympia, Thurston Co., Washington. See **Table 1** for coordinates. Larry Le Clair, Suzi Reszczynski, & Jesse Schultz! 10 Dec 2009; Allen Pleus, Wil Morris, & Jesse Schultz! 11 Dec 2009; Larry, Le Clair & Wil Morris! 14 Dec 2009

5) Capitol Lake, North Basin, Marathon Park, Olympia, Thurston Co., Washington. 47.03728º N 122.90973º W. 4' elev. Original site *P. antipodarum* was found at. In shallow water <10 cm depth, attached to a *Anodonta* shell (empty). *P. antipodarum and Anodonta* hand collected. Bert Bartleson! 22 Oct 2009.

6) Deschutes River at Tumwater Falls Park, Olympia, Thurston Co., Washington. Kick-net. Allen Pleus! 03 Dec 2009.

7) Deschutes River at Pioneer Park, Lacey, Thurston Co., Washington. Kick-net. Allen Pleus! 03 Dec 2009.

8) Deschutes River at Military Road SE bridge, Thurston Co., Washington. Kick-net. Allen Pleus! 03 Dec 2009.

9) Capitol Lake boat launch, North Basin, Olympia, Thurston Co., Washington. Kick-net? Allen Pleus! 03 Dec 2009.

10) Percival Cr. site #1, Tumwater, Thurston Co., Washington. Kick-net. Kick-net. Allen Pleus! 09 Dec 2009.

11) Percival Cr. site #5, Tumwater, Thurston Co., Washington. Kick-net. Allen Pleus! 09 Dec 2009.

APPENDIX B: LAB DATA SHEETS. CAPITOL LAKE SITES.

DEIXIS CONSULTANTS
LAB DATA SHEET

LOCALITY: Capitol Lake DATE COLLECTED: 12/10/2009 PAGE: 1
COLLECTORS: Larry Le Clair, Suzi Reszczynski, Jesse Schultz

SPECIES	TRANSECT	NO. LIVE	NO. DEAD	REMARKS
Potamopyrgus antipodarum	1A surface	1	22	1 live; 16 recent dead (bodies present); 6 long dead
Stagnicola sp.	1A surface	0	2	Recent dead (empty)
Physella gyrina	1A surface	0	3	1 recent dead (body present); 2 long dead
-	1A 1 foot	0	0	No mollusks. Slag in substrate
-	1A 2 foot	0	0	No mollusks. Slag in substrate
Potamopyrgus antipodarum	1A log	1	19	1 live; 18 recent dead (bodies present); 1 long dead
Potamopyrgus antipodarum	1B surface	1	54	1 live; 54 recent dead (bodies present)
Anodonta oregonensis?	1B surface	0	1	Recent dead (shell fragment)
Corbicula juv.	1B surface	0	3	Long dead (3 single valves)
-	1B 1 foot	0	0	No mollusks
-	1B 2 foot	0	0	No mollusks
Potamopyrgus antipodarum	2A surface	9	3	9 live; 1 recent dead (no body); 2 long dead
-	2A 1 foot	0	0	No mollusks
-	2A 2 foot	0	0	No mollusks
Potamopyrgus antipodarum	2B surface	27	6	27 live; 1 recent dead (body present); 5 recent dead (empty)
Radix auricularia	2B surface	1	0	Live
Stagnicola sp.	2B surface	0	1	Long dead
Potamopyrgus antipodarum	2B 1 foot	0	1	Recent dead (no body)
Potamopyrgus antipodarum	2B 2 foot	2	2	2 live; 2 recent dead (empty)
Potamopyrgus antipodarum	3A surface	12	13	12 live; 11 recent dead (bodies present); 2 long dead
Physella gyrina	3A surface	0	2	Long dead
-	3A 1 foot	0	0	No mollusks
Potamopyrgus antipodarum	3A 2 foot	5	1	5 live; 1 recent dead (body present)
Potamopyrgus antipodarum	3B surface	7	10	7 live; 8 recent dead (bodies present); 2 long dead
Potamopyrgus antipodarum	3B 1 foot	8	0	Live
Corbicula fluminea	3B 1 foot	2	0	Live
-	3B 2 foot	0	0	No mollusks
Potamopyrgus antipodarum	4A surface	0	1	Long dead
-	4A 1 foot	0	0	No mollusks
-	4A 2 foot	0	0	No mollusks
Potamopyrgus antipodarum	4B surface	20	4	20 live; 4 recent dead (empty)
Corbicula fluminea	4B surface	1	1	1 live juvenile; 1 long dead adult
Stagnicola sp.	4B surface	0	1	Long dead
-	4B 1 foot	0	0	No mollusks
-	4B 2 foot	0	0	No mollusks

DEIXIS CONSULTANTS
LAB DATA SHEET

LOCALITY: Capitol Lake DATE COLLECTED: 12/11/2009 PAGE: 1
COLLECTORS: Allen Pleus, Wil Morris, Jesse Schultz

SPECIES	TRANSECT	NO. LIVE	NO. DEAD	REMARKS
Potamopyrgus antipodarum	1A surface	0	12	8 recent dead (bodies present); 2 recent dead (empty); 2 long dead
Stagnicola sp.	1A surface	0	2	Recent dead (empty)
Physella gyrina	1A surface	0	1	Recent dead (no body)
-	1A 1 foot	0	0	No mollusks. Slag in substrate
-	1A 2 foot	0	0	No mollusks. Slag in substrate
Potamopyrgus antipodarum	1B surface	5	13	5 live; 4 recent dead (bodies present); 2 recent dead (empty); 7 long dead
Planorbella subcrenata	1B surface	1	0	Live
Physella gyrina	1B surface	0	1	Recent dead (empty)
-	1B 1 foot	0	0	No mollusks
-	1B 2 foot	0	0	No mollusks
Potamopyrgus antipodarum	2A surface	2	8	2 live; 1 recent dead (no body); 7 long dead
Stagnicola sp.	2A surface	0	1	Long dead
Physella gyrina	2A surface	0	1	Recent dead (no body)
-	2A 1 foot	0	0	No mollusks
-	2A 2 foot	0	0	No mollusks
Potamopyrgus antipodarum	2B surface	4	12	4 live; 12 recent dead (bodies present)
sphaeriid	2B surface	0	1	Long dead (single valve)
Potamopyrgus antipodarum	2B 1 foot	1	1	1 live; 1 long dead
Potamopyrgus antipodarum	2B 2 foot	0	5	1 recent dead (body present); 3 recent dead (empty); 1 long dead
Potamopyrgus antipodarum	3A surface	11	4	11 live; 4 long dead
-	3A 1 foot	0	0	No mollusks
-	3A 2 foot	0	0	No mollusks
Potamopyrgus antipodarum	3B surface	6	10	6 live; 3 recent dead (bodies present); 7 recent dead (empty)
Corbicula fluminea	3B surface	2	0	Live (1 juvenile & 1 adult)
Potamopyrgus antipodarum	3B 1 foot	0	6	2 recent dead (empty); 4 long dead
Corbicula fluminea	3B 1 foot	0	3	Recent dead (1 juvenile & 2 adults)
Potamopyrgus antipodarum	3B 2 foot	1	6	1 live; 5 recent dead (empty); 1 long dead
Potamopyrgus antipodarum	4A surface	0	1	Long dead (fragment)
-	4A 1 foot	0	0	No mollusks
-	4A 2 foot	0	0	No mollusks
Potamopyrgus antipodarum	4B surface	5	2	5 live; 2 long dead
-	4B 1 foot	0	0	No mollusks
-	4B 2 foot	0	0	No mollusks

DEIXIS CONSULTANTS
LAB DATA SHEET

LOCALITY: Capitol Lake DATE COLLECTED: 12/11/2009 PAGE: 2
COLLECTORS: Allen Pleus

SPECIES	TRANSECT	NO. LIVE	NO. DEAD	REMARKS
Potamopyrgus antipodarum	PA1	0	16	16 recent dead (mushy bodies present)
Potamopyrgus antipodarum	PA2	8	9	8 live; 7 recent dead (bodies present); 2 long dead; collected off *Anodonta oregonensis* shell
Potamopyrgus antipodarum	PA3	0	2	1 recent dead (mushy body present); 1 recent dead (no body). Collected from frozen mud chunk
Potamopyrgus antipodarum	PB4	0	17	12 recent dead (mushy bodies present); 5 recent dead (empty)
Potamopyrgus antipodarum	PC5	0	5	Recent dead (mushy bodies present); organic floatsom substrate
Potamopyrgus antipodarum	PD6	0	16	Recent dead (mushy bodies present)
Potamopyrgus antipodarum	PD7	0	17	Recent dead (mushy bodies present)

DEIXIS CONSULTANTS

LAB DATA SHEET

LOCALITY: Capitol Lake DATE COLLECTED: 12/14/2009 PAGE: 1

COLLECTORS: Wil Morris, Larry Le Clair

SPECIES	TRANSECT	NO. LIVE	NO. DEAD	REMARKS
Potamopyrgus antipodarum	1A surface	0	4	2 recent dead (bodies present); 2 recent dead (empty)
-	1A 1 foot	0	0	No mollusks. Slag in substrate
Potamopyrgus antipodarum	1B surface	1	13	1 live; 13 recent dead (empty)
-	1B 1 foot	0	0	No mollusks
Potamopyrgus antipodarum	2A surface	0	9	5 recent dead (bodies present); 4 recent dead (no body)
-	2A 1 foot	0	0	No mollusks
Potamopyrgus antipodarum	2B surface	1	19	1 live; 6 recent dead (body present); 13 recent dead (empty)
Stagnicola sp.	2B surface	0	1	Recent dead (body present
Potamopyrgus antipodarum	2B 1 foot	0	1	Recent dead (body present)
Potamopyrgus antipodarum	3A surface	2	30	2 live; 10 recent dead (bodies present); 20 long dead
Potamopyrgus antipodarum	3A 1 foot	0	1	Long dead
Potamopyrgus antipodarum	3B surface	1	14	1 live; 5 recent dead (bodies present); 9 recent dead (empty)
Physella gyrina	3B surface	0	1	1 recent dead (body present)
-	3B 1 foot	0	0	none
Potamopyrgus antipodarum	4A surface	0	14	1 recent dead (empty); 13 long dead
Corbicula fluminea	4A surface	0	1	½ valve long dead
Physella gyrina	4A surface	0	1	Recent dead (no body)
-	4A 1 foot	0	0	No mollusks
Potamopyrgus antipodarum	4B surface	0	13	5 recent dead (bodies present); 7 recent dead (empty); 1 long dead
Corbicula fluminea	4B 1 foot	0	2	Long dead

APPENDIX C: LAB DATA SHEET. DESCHUTES RIVER, CAPITOL LAKE, AND PERCIVAL CREEK SITES.

DEIXIS CONSULTANTS

LAB DATA SHEET

SPECIES	LOCALITY	COLLECTOR:	DATE COLL:	NO. LIVE	NO. DEAD	REMARKS
Fluminicola n. sp.	Deschutes R. at Tumwater Falls Park	Allen Pleus	12/03/2009	4	0	2 adults; 2 juveniles
Juga n. sp.	"	"	"	2	0	Juveniles
Fluminicola n. sp.	Deschutes R. at Pioneer Park	"	"	9	0	4 subadults; 5 juveniles
Juga n. sp.	"	"	"	3	0	1 adult; 2 juveniles
Physella gyrina	"	"	"	1	0	Adult
Fluminicola n. sp.	Deschutes R. at Military Rd. SE bridge	"	"	5	0	3 adults; 1 subadult; 1 juvenile
Juga n. sp.	"	"	"	12	0	1 adult; 3 subadults; 8 juveniles
Juga n. sp.	Capitol Lk. boat launch	"	"	7	0	Adults
Potamopyrgus antipodarum	"	"	"	0	2	1 recent dead (bodies present); 1 long dead
Stagnicola	"	"	"	2	0	Adults
Juga n. sp.	Percival Cr. site #1	"	12/09/2009	1	0	Adult
-	Percival Cr. site #2	"	"	0	0	No mollusks
-	Percival Cr. site #3	"	"	0	0	No mollusks
-	Percival Cr. site #4	"	"	0	0	No mollusks
Juga n. sp.	Percival Cr. site #5	"	"	0	0	Juvenile
Stagnicola	"	"	"	1	0	Adult
Physella gyrina	"	"	"	1	0	Adult

TABLES

TABLE 1. COORDINATES FOR TRANSECT SITES COLLECTED FROM CAPITOL LAKE.

TRANSECT SITES	FIELD SAMPLE DATE	FIELD SAMPLE TIME	LAB SAMPLE DATE	LAB SAMPLE TIME	LONGITUDE	LATITUDE
Site 1 A surface	12/10/09	1022	12/11/09	1036	47.0384	-122.9062
Site 1 A 1	12/10/09	1013	12/11/09	1627	47.0384	-122.9062
Site 1 A 2	12/10/09	1018	12/11/09	1520	47.0384	-122.9062
Site 1 B surface	12/10/09	1020	12/11/09	1420	47.0385	-122.9062
Site 1 B 1	12/10/09	1006	12/11/09	1556	47.0385	-122.9062
Site 1 B 2	12/10/09	1006	12/11/09	1540	47.0385	-122.9062
Site 2 A surface	12/10/09	1120	12/11/09	1436	47.0384	-122.9063
Site 2 A 1	12/10/09	1123	12/11/09	1216	47.0384	-122.9063
Site 2 A 2	12/10/09	1129	12/11/09	1350	47.0384	-122.9063
Site 2 B surface	12/10/09	1109	12/11/09	1140	47.0385	-122.9063
Site 2 B 1	12/10/09	1112	12/11/09	1300	47.0385	-122.9063
Site 2 B 2	12/10/09	1015	12/11/09	1015	47.0385	-122.9063
Site 3 A surface	12/10/09	1102	12/11/09	1250	47.0383	-122.9064
Site 3 A 1	12/10/09	1104	12/11/09	1606	47.0383	-122.9064
Site 3 A 2	12/10/09	1107	12/11/09	1531	47.0383	-122.9064
Site 3 B surface	12/10/09	1048	12/11/09	1502	47.0384	-122.9065
Site 3 B 1	12/10/09	1050	12/11/09	1211	47.0384	-122.9065
Site 3 B 2	12/10/09	1058	12/11/09	1325	47.0384	-122.9065
Site 4 A surface	12/10/09	1040	12/11/09	1405	47.0383	-122.9067
Site 4 A 1	12/10/09	1042	12/11/09	1615	47.0383	-122.9067
Site 4 A 2	12/10/09	1044	12/11/09	1548	47.0383	-122.9067
Site 4 B surface	12/10/09	1029	12/11/09	1455	47.0384	-122.9067
Site 4 B 1	12/10/09	1030	12/11/09	1510	47.0384	-122.9067
Site 4 B 2	12/10/09	1032	12/11/09	1330	47.0384	-122.9067

TABLE 1. COORDINATES FOR TRANSECT SITES COLLECTED FROM CAPITOL LAKE. (cont.)

TRANSECT SITES	FIELD SAMPLE DATE	FIELD SAMPLE TIME	LAB SAMPLE DATE	LAB SAMPLE TIME	LONGITUDE	LATITUDE
Site 1 A surface	12/11/09	1349	12/12/09	1447	47.0384	-122.9062
Site 1 A 1	12/11/09	1400	12/12/09	1448	47.0384	-122.9062
Site 1 A 2	12/11/09	1412	12/12/09	1620	47.0384	-122.9062
Site 1 B surface	12/11/09	1404	12/12/09	1634	47.0385	-122.9062
Site 1 B 1	12/11/09	1410	12/12/09	1725	47.0385	-122.9062
Site 1 B 2	12/11/09	1415	12/12/09	1740	47.0385	-122.9062
Site 2 A surface	12/11/09	1421	12/12/09	1506	47.0384	-122.9063
Site 2 A 1	12/11/09	1425	12/12/09	1722	47.0384	-122.9063
Site 2 A 2	12/11/09	1432	12/12/09	1743	47.0384	-122.9063
Site 2 B surface	12/11/09	1428	12/12/09	1530	47.0385	-122.9063
Site 2 B 1	12/11/09	1453	12/12/09	1640	47.0385	-122.9063
Site 2 B 2	12/11/09	1459	12/12/09	1649	47.0385	-122.9063
Site 3 A surface	12/11/09	1445	12/12/09	1430	47.0383	-122.9064
Site 3 A 1	12/11/09	1453	12/12/09	1540	47.0383	-122.9064
Site 3 A 2	12/11/09	1459	12/12/09	1704	47.0383	-122.9064
Site 3 B surface	12/11/09	1505	12/12/09	1714	47.0384	-122.9065
Site 3 B 1	12/11/09	1510	12/12/09	1725	47.0384	-122.9065
Site 3 B 2	12/11/09	1520	12/12/09	1618	47.0384	-122.9065
Site 4 A surface	12/11/09	1504	12/12/09	1503	47.0383	-122.9067
Site 4 A 1	12/11/09	1508	12/12/09	1650	47.0383	-122.9067
Site 4 A 2	12/11/09	1515	12/12/09	1519	47.0383	-122.9067
Site 4 B surface	12/11/09	1522	12/12/09	1620	47.0384	-122.9067
Site 4 B 1	12/11/09	1527	12/12/09	1700	47.0384	-122.9067
Site 4 B 2	12/11/09	1530	12/12/09	1704	47.0384	-122.9067

TABLE 1. COORDINATES FOR TRANSECT SITES COLLECTED FROM CAPITOL LAKE. (cont.)

TRANSECT SITES	FIELD SAMPLE DATE	FIELD SAMPLE TIME	LAB SAMPLE DATE	LAB SAMPLE TIME	LONGITUDE	LATITUDE
Site 1 A surface	12/14/09	850	12/15/09	1603	47.0384	-122.9062
Site 1 A 1	12/14/09	855	12/15/09	1550	47.0384	-122.9062
Site 1 A 2	-	-	-	-	-	-
Site 1 B surface	12/14/09	900	12/15/09	1520	47.0385	-122.9062
Site 1 B 1	12/14/09	905	12/15/09	1540	47.0385	-122.9062
Site 1 B 2	-	-	-	-	-	-
Site 2 A surface	12/14/09	840	12/15/09	1618	47.0384	-122.9063
Site 2 A 1	12/14/09	845	12/15/09	1608	47.0384	-122.9063
Site 2 A 2	-	-	-	-	-	-
Site 2 B surface	12/14/09	842	12/15/09		47.0385	-122.9063
Site 2 B 1	12/14/09	845	12/15/09	1527	47.0385	-122.9063
Site 2 B 2	-	-	-	-	-	-
Site 3 A surface	12/14/09	830	12/15/09	1630	47.0383	-122.9064
Site 3 A 1	12/14/09	830	12/15/09	1625	47.0383	-122.9064
Site 3 A 2	-	-	-	-	-	-
Site 3 B surface	12/14/09	835	12/15/09	1535	47.0384	-122.9065
Site 3 B 1	12/14/09	840	12/15/09	1500	47.0384	-122.9065
Site 3 B 2	-	-	-	-	-	-
Site 4 A surface	12/14/09	815	12/15/09	1655	47.0383	-122.9067
Site 4 A 1	12/14/09	820	12/15/09	1650	47.0383	-122.9067
Site 4 A 2	-	-	-	-	-	-
Site 4 B surface	12/14/09	825	12/15/09	1639	47.0384	-122.9067
Site 4 B 1	12/14/09	840	12/15/09	1545	47.0384	-122.9067
Site 4 B 2	-	-	-	-	-	-

- = site not collected

TABLE 2. *POTAMOPYRGUS ANTIPODARUM* LIVE AND DEAD COLLECTED FROM CAPITOL LAKE ON 12/10/2009.

TRANSECT	LIVE	RECENT DEAD WITH BODIES	RECENT DEAD EMPTY SHELLS	LONG DEAD
1A surface	1	16	0	6
1A 1 foot	0	0	0	0
1A 2 foot	0	0	0	0
1B surface	1	54	0	0
1B 1 foot	0	0	0	0
1B 2 foot	0	0	0	0
2A surface	9	0	1	2
2A 1 foot	0	0	0	0
2A 2 foot	0	0	0	0
2B surface	27	1	5	0
2B 1 foot	0	0	1	0
2B 2 foot	2	0	2	0
3A surface	12	11	0	2
3A 1 foot	0	0	0	0
3A 2 foot	5	1	0	0
3B surface	7	8	0	2
3B 1 foot	8	0	0	0
4A surface	0	0	0	1
4A 1 foot	0	0	0	0
4A 2 foot	0	0	0	0
4B surface	20	0	4	0
4B 1 foot	0	0	0	0
4B 2 foot	0	0	0	0
1A log	1	18	0	1

TABLE 3. *POTAMOPYRGUS ANTIPODARUM* LIVE AND DEAD COLLECTED FROM CAPITOL LAKE ON 12/11/2009.

TRANSECT	LIVE	RECENT DEAD WITH BODIES	RECENT DEAD EMPTY SHELLS	LONG DEAD
1A surface	0	8	2	2
1A 1 foot	0	0	0	0
1A 2 foot	0	0	0	0
1B surface	5	4	2	7
1B 1 foot	0	0	0	0
1B 2 foot	0	0	0	0
2A surface	2	0	1	7
2A 1 foot	0	0	0	0
2A 2 foot	0	0	0	0
2B surface	4	12	0	0
2B 1 foot	1	0	0	1
2B 2 foot	0	1	3	1
3A surface	11	0	0	4
3A 1 foot	0	0	0	0
3A 2 foot	0	0	0	0
3B surface	6	3	7	0
3B 1 foot	0	0	2	4
3B 2 foot	1	0	5	1
4A surface	0	0	0	1
4A 1 foot	0	0	0	0
4A 2 foot	0	0	0	0
4B surface	5	0	0	2
4B 1 foot	0	0	0	0
4B 2 foot	0	0	0	0
PA1	0	16	0	0
PA2	8	7	0	2
PA3	0	1	1	0
PB4	0	12	5	0
PC5	0	5	0	0
PD6	0	16	0	0
PD7	0	17	0	0

TABLE 4. *POTAMOPYRGUS ANTIPODARUM* LIVE AND DEAD COLLECTED FROM CAPITOL LAKE ON 12/14/2009.

TRANSECT	LIVE	RECENT DEAD WITH BODIES	RECENT DEAD EMPTY SHELLS	LONG DEAD
1A surface	0	2	2	0
1A 1foot	0	0	0	0
1A 2 foot	-	-	-	-
1B surface	1	0	13	0
1B 1 foot	0	0	0	0
1B 2 foot	-	-	-	-
2A surface	0	5	4	0
2A 1 foot	0	0	0	0
2A 2 foot	-	-	-	-
2B surface	1	6	13	0
2B 1 foot	0	1	0	0
2B 2 foot	-	-	-	-
3A surface	2	10	0	20
3A 1 foot	0	0	0	1
3A 2 foot	-	-	-	-
3B surface	1	5	9	0
3B 1 foot	0	0	0	0
3B 2 foot	-	-	-	-
4A surface	0	0	1	13
4A 1 foot	0	0	0	0
4A 2 foot	-	-	-	-
4B surface	0	5	7	1
4B 1 foot	0	0	0	0
4B 2 foot	-	-	-	-

- = sites not collected

TABLE 5. PERCENT CHANGE IN LIVE *POTAMOPYRGUS ANTIPODARUM* BETWEEN SAMPLE DATES.

TRANSECT	NUMBER LIVE ON 12/10/09	NUMBER LIVE ON 12/11/09	NUMBER LIVE ON 12/14/09	PERCENT CHANGE BETWEEN 12/10 & 12/11	PERCENT CHANGE BETWEEN 12/11 & 12/14	PERCENT CHANGE BETWEEN 12/10 & 12/14
1A surface	1	0	0	-	-	-
1B surface	1	5	1	400%	-80.0%	-85.7%
2A surface	9	2	0	-77.8%	-	-
2B surface	27	4	1	-85.2%	-75.0%	-96.3%
3A surface	12	11	2	-8.3%	-77.8%	-83.3%
3B surface	7	6	1	-14.3%	-83.3%	-85.7%
4A surface	0	0	0	-	-	-
4B surface	20	5	0	-75.0%	-	-
AVERAGE	9.625	4.125	0.625	-42.9%	-84.8%	-99.4%

Percent change is calculated by subtracting the difference between numbers live on the second sample date by the number live on the first sample date and dividing by the number live on the first sample date, then multiplying by 100 to express the result as percentage change.

TABLE 6. AIR TEMPERATURE RECORDS FROM SWANTOWN MARINA WEATHER STATION, OLYMPIA, WASHINGTON (LAT. 47.055º N, LONG. -122.898º W).

DATE	HIGH ºF	LOW ºF	AVERAGE ºF
12/08/2009	30.1	15.1	21.6
12/09/2009*	31.2	15.1	22.1
12/10/2009	**32.9**	**14.9**	**23.0**
12/11/2009	**34.3**	**18.9**	**25.8**
12/12/2009	35.8	22.1	28.8
12/13/2009	35.3	25.6	30.9
12/14/2009	**42.6**	**34.9**	**38.5**

Available at http://www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=KWAOLYMP8
*=date of Capitol Lake drawdown.
Bold=dates samples were taken.